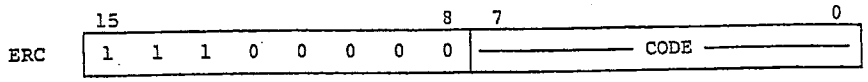
EXHIBIT 7
(PART 3 OF 4)

SECTION 16
ERROR CODE

Error Code - ERC



Whenever an error condition is generated, the Display Generator sets DSTAT C and transmits to the host the error word, ERC (see Appendix A). The eight least significant bits describe the error as follows:

CODE

1. Host / 5216 Communications Error
2 Undefined
3 Cursor out of limits
4 Undefined
5 Undefined
6 Undefined
7 Undefined
8 Illegal (syntax) instruction
9 Undefined
10-15 Undefined

To reset Attention and DSTAT C, pulse Function 3. The host must read all three words in the error message in order to clear the 5216 for further operation.

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SECTION 17

FUNCTION KEY DESCRIPTIONS

The 5216 Display Computer can support one or two keyboards in a minimum configuration, and as many as 10 keyboards when two optional Serial Input/Output (SIO) cards are included.

The keyboard is the AYDIN 5116 Display Editor, which has a full alphanumeric set, Greek letters, and a separate number keypad. Four cursor keys move the cursor.

There is a set of 27 preprogrammed function keys designed to perform many of the instructions of the Standard Firmware. Many powerful graphic display functions can be performed using these preprogrammed keys. The keyboard also supports a trackball or joystick, and a 45-function keypad for user-programmed functions.

Each keyboard is associated with a particular parameter set at Power Up. This association can be changed so that any keyboard can be associated with any parameter set.

Normally, keyboard functions cause graphic display on the AYDIN CRT monitor. However, the programmer can change a control word (Keyboard Transmit Status) so that keyboard information is sent across the Input/Output Controller (IOC) card to the host computer without changing the 5216 display.

In addition to function keys that control display, some keys are used to store data in 5216 RAM. The LOAD KEYBOARD BUFFER (LKB) key is used to store sequences of keyboard function keys. The MEMORY key is used to store data in any memory location in the 20-bit address space of the 5216 Display Computer.

With the exception of the first (numerical) entry, the following descriptions of the function keys of the 5116 keyboard are arranged alphabetically.

Each entry is named for the function it performs, and, where applicable, keytop mnemonics are given.

5 x 7
7 x 9
10 x 14

See FONT SELECT

ADD

This function key has the same effect as the OR 1's Memory Input Mode. In the Add mode, input pixel data is OR'd with the existing data and the result is stored as display data. For example, if a pixel value of $00F0_H$ is entered in Add mode to a location which already contains $000F_H$, the resulting data will be $00FF_H$.

This holds true in either Word or Pixel mode. In Pixel mode, data input for vectors, circles, and write graphics comes from the Foreground Pixel Register (FPR), and for characters in Add mode, the character is drawn from the FPR and the background block is input from the Background Pixel Register (BPR).

In Word mode, the above operations hold true, but the FPR is effectively all 1's and the BPR is all 0's.

Input data can only be entered to selected memory channels within the rectangular limits.

BACKGROUND - BKGD

This function key is used only when Replace mode is selected. When Add or Erase modes are selected, this function is ignored.

1. Normal. In Replace Normal, input data will replace existing data. Characters will be written from the FPR on backgrounds written from the BPR. Graphic data will be input using the FPR value.

2. Reverse. When Reverse is selected, character data will be input using the BPR and the background block will be input using data stored in the FPR. For Conics and Write Graphic input, Reverse Replace will have the same effect as Replace Normal. Input data will have the value stored in the FPR.

The above functional descriptions hold true for Pixel as well as Word mode. For Word mode, the FPR is effectively all 1's, and the BPR is effectively all 0's.

This key will be ignored if the Replace mode is not currently selected.

BACKGROUND PIXEL - B/PIXL

This function is used to load the Background Pixel Register (BPR). Input to this function can be made in two ways:

1. After keying the function, a four-digit hex value can be entered, followed by a carriage return. Only the binary digits of the entered number which correspond to actual memory planes in the system will have meaning.

2. a. Select the pallet (see PALLET).
   b. Locate the cursor on the desired color on the pallet display.
   c. Select MOVE G.
   d. Press the B/PIXL function key, followed by a circumflex (^).

This procedure loads the pixel value corresponding to the displayed color into the register.

In Replace Normal mode, the value in the BPR is used in the background block of alphanumeric characters.

In Replace Reverse mode, the value in the BPR is used for the alphanumeric character.

In Erase mode, the BPR value is used to generate vectors, circles, and write graphics.

In Word mode, the BPR is automatically set to all 0's. However, selecting the Word mode will not destroy the contents of the BPR.

BUFFER - XMIT

In Graphic mode (see KEYBOARD key), the Buffer - XMIT key transmits an ASCII code (90_H) to the host computer.

The keytop engraving (Buffer- XMIT) refers to transmitting data from the ANCS. This is only used when the ANCS is being programmed directly, i.e., the KEYBOARD key is set to Alpha mode. (See ANCS user's documentation.)

See XMIT.

CENTER

This function positions the cursor to the center of the rectangular window.

CIRCLE

Circles are drawn with the center at the index location. (See LOAD INDEX.) The radius is determined by the X difference between the cursor position and the index. The cursor will be repositioned at the center of the circle.

Memory Input Mode will affect circle data in exactly the same way as it affects vectors. (Refer to Vectors)

Notice that concentric circles may be drawn by moving the cursor in the X direction and pressing the Execute Circle key.

When executing circles from the host, the center is the cursor location, and the radius is the X index.

CLEAR

All enabled memory planes are cleared to 0's within the rectangular window. Memory planes which are not selected will not be cleared.

CLEAR TO 1's - CLR 1

When this function is keyed, all locations within the rectangular limits are set to 1's (for all selected memory planes).

CLEAR CONIC LIMIT - CCL

Keying this function clears the conic limits, and the conic rectangle becomes the full screen.

CLEAR RECTANGULAR LIMITS - CRL

Keying this function clears the rectangular window limits to the full screen.

COPY

This function copies pixel data from one rectangular area of the screen and places it into another. The area to be copied to is defined by the rectangular conic limits window. The area to be copied from is defined by the size of the conic limit window, and is located on the screen using the cursor position as its center.

The Copy function key will handle one or two fields of data depending on the choice of delimiter characters. The Copy function is instructed as to which pixels are to be copied through the specification of either a particular pixel value or a range of pixel values.

Since the Copy function selectively copies pixels, it may be used to copy a window onto itself by locating the cursor in the center of the conic window.

In the Copy function, there are "foreground" pixel values defined by the field values input after Copy is keyed; correspondingly, the "background" pixel values are defined by all values not included in the foreground direction. These "foreground" and "background" values apply only to the operation of the Copy function.

In this section, the words "foreground" and "background" are enclosed in quotation marks to indicate values defined only by the Copy function. They are unrelated to the Foreground and Background Pixel Registers, and they are not recorded in any register for use outside the Copy function.

The "foreground" values are always copied by the Copy function. The "background" values will be ignored, replaced by 0's, or replaced by the value in the BPR, depending on the mode selected at the time Copy is called.

In the Add mode, "background" pixels are ignored.

In the Replace mode, there is a further check to see if Word mode or Pixel mode is selected. If Word mode is selected, the "background" pixel values are copied as 0's. If Pixel mode is selected, the "background" pixel values are copied as the value stored in the BPR.

The "foreground" values are always copied by the Copy function, and are defined as follows:

If a four-digit hex value is typed after the Copy function and followed by a carriage return, "foreground" pixel values are defined as any pixel value which gives a non-zero result when ANDed with the input value. For example, if a 7 is entered and followed by a carriage return, any pixel with

bits 0, 1, or 2 set will be a "foreground" value.

If a pixel value is typed and followed by a circumflex (^), "foreground" values are only the typed value.

If a four-digit hex pixel value is typed and followed by a comma, another four-digit hex value will be expected.

If this next value is followed by a carriage return, "foreground" pixel values are all values which fall between the first and second value typed.

If the second value is followed by a circumflex (^), "foreground" values are defined as all pixel values which do not fall within the range between the first and second values typed.

In order to copy an entire image unchanged, $FFFE_H$ can be typed, followed by a carriage return. This will define all pixels as "foreground" values so that all pixels are copied. This should be done in Replace mode and Word mode so that 0 pixels will not be replaced by the Background Pixel Register (BPR).

First Number Followed by:	Second Number Followed by:	Will Copy
Carriage Return	_____	Non-zero after AND
^ (circumflex)	_____	Equals
, (comma)	Carriage Return	Within Range
, (comma)	^ circumflex	Not in Range

Memory Input Mode	Pixel/Word Mode	Pixels not Copied into will be:
OR 1's	Don't Care	Not Changed
ERASE 1's	Don't Care	Not Changed
Replace Normal or Reverse	Word	Set to Zero
Replace Normal or Reverse	Pixel	Set to Background Pixel Register Value

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CURSOR - XMIT

In Graphic mode (see Keyboard- KBYD key), this key transmits an ASCII code (AE_H) to the host computer.

The keytop engraving (Cursor - XMIT) refers to transmitting data from the ANCS. This is only used when the ANCS is being programmed directly (KYBD key set to Alpha mode). See ANCS user's documentation.

See XMIT.

DC POWER

This is an on/off indicator light and not a button.

DESTRUCTIVE - DEST

This function selects a Destructive mode for roll and scroll. In the Destructive mode, data moved off the screen by roll or scroll is lost (no wrap around).

EAROM

This key (with no shift) is no longer functional.

ERASE

For vectors, circles, and write graphics, the Erase function causes displayed data to be replaced by the pixel value stored in the BPR. (In Word mode, the BPR is effectively all 0's, so that the Erase in Word mode causes 0's to be entered in all selected memory planes.)

When characters are being generated, Erase mode performs a different operation. Input data is selected from the Foreground Pixel Register (FPR) for the character, and from the BPR for the background block, as is the case for characters written in Replace Normal mode. However, instead of being replaced, the existing display data is erased to 0 wherever the input data contains a 1, and is left unchanged wherever the input data contains a 0.

For example, if a display area contains pixels containing the value 0007_H and a character is keyed in Erase mode with the FPR value 0006_H and BPR value 0001_H, the display data would be changed to 0001_H at the location of the character, and would have the value 0006_H in the locations defined by

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the background block of the character.

In Word mode, Erase performs the same operation as in Pixel mode, except that the FPR will effectively contain all 1's and the BPR will effectively contain all 0's.

See MODE- Add, Replace

EXECUTE CACHE BUFFER - XCB

This function executes the Cache Buffer. The Cache Buffer is loaded by the host computer using the Load Cache Buffer (LCB) command. The Cache Buffer can be either a sequence of 5216 Standard Firmware instructions, or a sequence of 8086 machine code instructions. When the Cache Buffer is executed, the sequence of commands is executed.

This command expects two data fields. The first field is either zero or non-zero. If it is zero, the Cache Buffer is executed in Display List mode, in which the words in the Cache Buffer are 5216 Standard Firmware instructions.

If the first field is non-zero, the instructions in the Cache Buffer are 8086 machine code. In this mode, the Cache Buffer contains a subroutine which uses a far call and a long return. It is followed by typing a carriage return. Then the second field is typed. This is a five-digit hex address field which specifies the beginning of the Cache Buffer.

After the second field is typed, a carriage return is keyed to start execution of the Cache Buffer.

EXECUTE KEYBOARD BUFFER - XKB

This function executes the Keyboard Buffer, which was loaded using the Load Keyboard Buffer (LKB) function key.

XKB expects a five-digit hex address, which is the starting address of the Keyboard Buffer to be executed, followed by a carriage return.

The address field is initialized to 0's.

The Keyboard Buffer is filled with ASCII codes generated either by alphanumeric characters or by function keys. When the Keyboard Buffer is executed, it performs the same function as the enabled keyboard.

Keyboard playback starts at the current cursor position at the beginning of execution.

Function keystrokes such as font size changes, cursor moves,

pixel value changes, vectors, circles, etc., may be entered in the Keyboard Buffer.

When the XKB function is initiated, it will take bytes one at a time from the buffer and execute them as though they were ASCII keystrokes. This will continue until a $9B_H$ keystroke is encountered (as entered into the Keyboard Buffer by the Terminate Keyboard Buffer function key).

FAST MODE

If the Fast Mode button is held down simultaneously with any character key (with or without a shift), characters are output at a rate of 500 per second. This also applies to cursor arrow keys.

FILL

This function is used to fill an area with a new pixel value. The area to be filled is selected by locating the cursor over any pixel in the area. The area is bounded by any pixel which does not equal the pixel value over which the cursor is located when the instruction is executed. The area to be filled is also bounded by the rectangular window limits.

The new pixel value with which the area is to be filled is the value in the Foreground Pixel Register (FPR).

Operation of this function is independent of Pixel or Word mode selection, Memory Input Mode (Add, Erase, or Replace), and Word or Pixel mode.

FONT SELECT - 5 x 7, 7 x 9, 10 x 14

Five fonts may be selected using keyboard function keys. These font functions will generate characters for screen display. The characters are built with a foreground and a background pixel value.

Three fonts are system loaded of size 5 x 7, 7 x 9, and 10 x 14.

The fourth font is for the special symbols engraved in the upper right hand corner of the character keys. These symbols are written in the 7 x 9 font size.

The fifth font is a programmable font which is loaded via the host computer and uses a 16 (horizontal) by 15 (vertical) font size.

Also, when either the 7 x 9 font or the special font is selected, the lower case letters and other special symbols engraved on the upper left of the keytops will be displayed when the keys are typed with a shift.

See PROGRAMMABLE FONT.

FOREGROUND PIXEL VALUE - F/PIXL

This function is used to place a value in the Foreground Pixel Register (FPR).

Input to this function can be done in two ways.

A four-digit hex value can be entered, followed by a carriage return. Only the binary digits of the entered number which correspond to actual memory planes in the system will have meaning. The low bit of the pixel value corresponds to the low memory plane.

The other way to load the FPR is to locate the cursor on the desired color of the pallet display. Select the MOVE G key, then hit F/PIXL, followed by a circumflex (^). (See PALLET.) This loads the number corresponding to the displayed color into the register.

In Replace Normal mode, the value in the FPR is used to draw vectors, circles, write graphics, and the characters in alphanumeric display.

In Replace Reverse mode, the Foreground Pixel value is used in the background rectangle of alphanumeric display.

In Add and Erase modes, the FPR value is used for input, however, the displayed result will depend on the further operation of the mode selected. (See ADD and ERASE.)

In Word mode, the FPR is effectively set to all 1's. However, the value which was in the FPR before Word mode was selected will not be lost and will be restored when Pixel mode is selected.

KEYBOARD - KYBD

This key selects the Keyboard mode. With a shift, this key specifies the Alphanumeric mode; without a shift, Graphics mode is specified. The default (Power Up) state of the system will depend on the hardwired configuration. In order to change from the Power Up state (either A/N or Graphics) to the opposite state, the KYBD function key is used.

In the Alphanumeric mode (shift), this function selects direct programming to the A/N channel set. The ANCS instruction set is different from the 5216 Standard Firmware instruction set. When the keyboard is wired to the ANCS, or when Alphanumeric Keyboard is selected, the function code keys will select ANCS instructions. These are documented in the ANCS user's manual. Additional instruction codes may be sent to the ANCS using the Select Device (SDEV) command of the 5216 Standard Firmware instruction set.

When the Graphics Keyboard (no shift) is selected, the keyboard is wired to the 5216 processor. This enables the function code keys to perform according to 5216 Standard Firmware operation.

(The KYBD function key does not select the display mode as specified by bit 0 of the Mode Control Word (MCW) of the Standard Firmware instruction set. In order to select the display mode as specified by the MCW bit 0, Write Graphic (WRIT G) or Move Graphic (MOVE G) can be keyed for Graphic display mode, and any font select may be keyed to select Alphanumeric display mode.)

Before displaying ANCS data on the monitor, the VID-004 status word must be loaded by keying the following sequence:

Graphic Keyboard
LOAD COLOR TABLE
Carriage Return
200
Carriage Return
F
Carriage Return
Alpha Keyboard

To discontinue VID-004 display of ANCS data, the above sequence is keyed with a 'B' in the data field instead of 'F'.

LEFT TOP CONIC - LTC

This key uses the cursor location to set the left top limit of the Conic Limits rectangle. The operator moves the cursor to the desired position and LTC is keyed to enter the left top of the limit rectangle.

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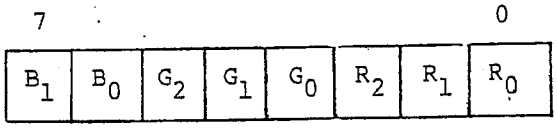
When the last field is followed by a carriage return, the value is entered and the function is terminated.

When the last field is followed by a comma, the value is entered and the address incremented. The input value field of the function key is then set to 0 and the function waits for the next value.

When the last field is followed by a circumflex, the value is entered and the address decremented. The input value field of the function key is set to zero and the function waits for the next value.

Comments

Color values for the VID-004 card are based on an eight-bit word where the least three bits drive the Red raster gun (with intensity levels from 0 to 7), the next three bits drive the Green raster gun, and the high two bits drive the Blue gun (intensity 0 to 3).



The color table address is a nine-bit address. The high eight bits are provided by the programmer or by the serial output of the memory channels and the low byte is always 0. Whatever pixel value is output by the refresh memory will be multiplied by two before it references an address in the lookup table. For example, pixel value 0001_H will reference lookup table address 0002_H.

The high bit of the nine-bit address is (optionally) AND'ed with a blink oscillator. This gives the effect of blinking between the two colors loaded in the lookup table at the particular address with and without the high bit set.

Any value may be loaded in any table location such that a pixel value will display the color value loaded in the corresponding lookup table location. For example, the zeroth position of the lookup table may be loaded with a 007_H so that clearing the pixel memory to all zeros will result in a red screen display. Loading LUT#1 using the LUT#1 function key will load an identity table into the lookup table so that the 00 entry contains color value 00, the 02 entry contains color value 01, etc.

Any element of the lookup table may be loaded with any color value using the Load Color Table function key and the identity table may be restored at any time by selecting the LUT #1 key.

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LEFT TOP RECTANGLE - LTR

This function uses the cursor location to set the left top corner of the rectangular window limits.

The rectangular limits may be set at any time anywhere on the screen without affecting data already displayed.

Data may be added or deleted only within the specified rectangular limits. For example, the Clear function key will clear only those pixels located within the rectangular limits. To enter data outside the rectangular limits, Clear Rectangular Limits (CRL) must be keyed.

LINE - XMIT

In Graphic mode (see Keyboard (KYBD) key), this key transmits an ASCII code ($9E_H$) to the host computer.

The keytop engraving (LINE - XMIT) refers to transmitting data from the Alphanumeric Channel Set (ANCS). This is only used when the ANCS is being programmed directly, i.e., KYBD key set to Alpha mode. (See ANCS user's documentation.)

See XMIT.

LOAD COLOR TABLE

Individual elements of the video lookup table may be loaded by this function key.

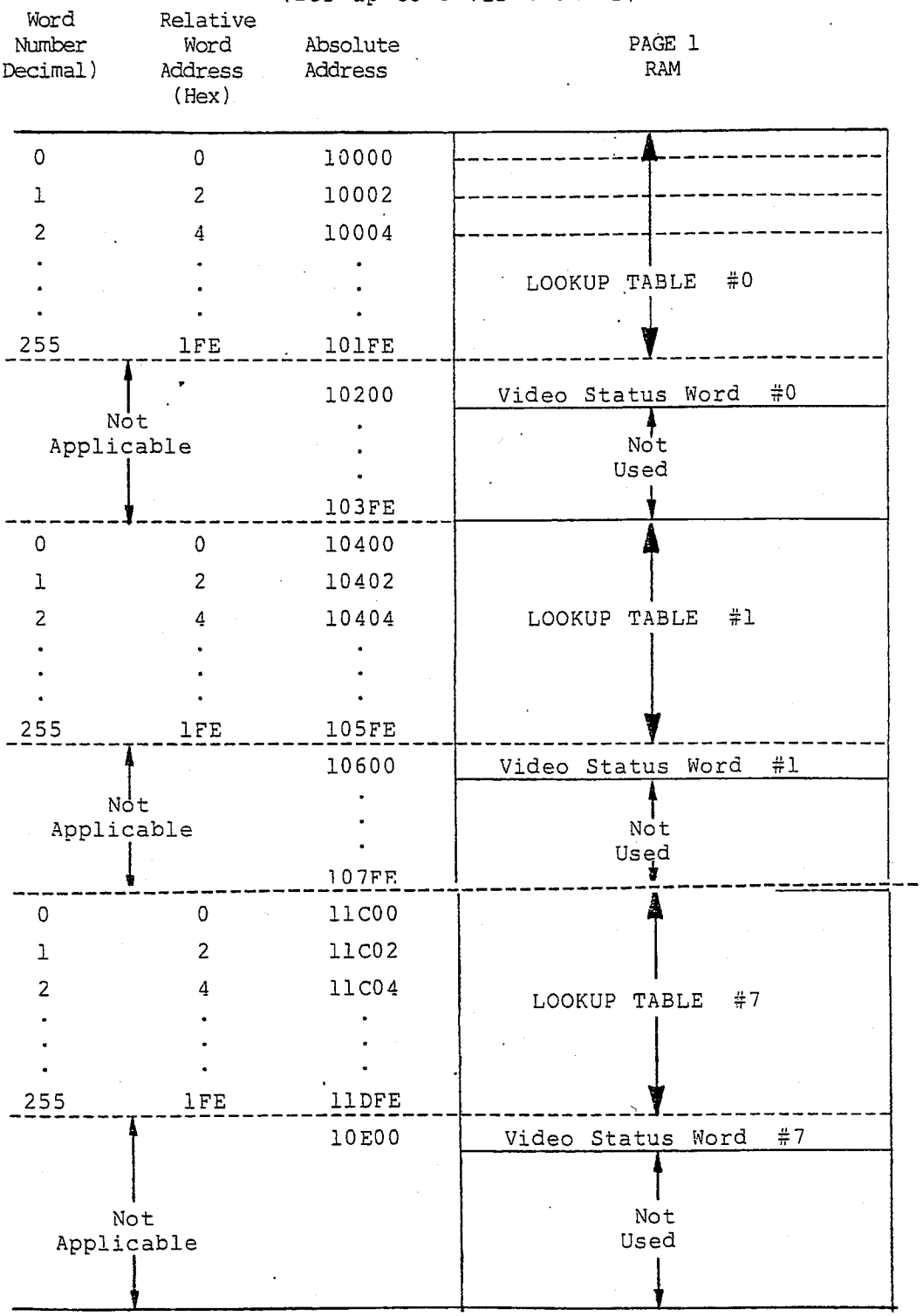
Operation

When the Load Color Table key is hit, three fields are expected. The first field is a one digit field indicating the number of the color table being loaded. This number refers to the particular VID-4 card to be loaded. Up to eight VID-4 cards, numbered 0 through 7 may be supported by Standard Firmware. For a system with only one VID-4 card, Table #0 should always be specified. This field is ended by a carriage return.

The second field contains the relative address, times two, of the color table value to be entered. For example, for the zeroth word of the lookup table (LUT), enter Ø; for the first word, enter 2, for the second word, enter 4, etc. This field is ended by a carriage return.

The last field of the Load Color Table key is the color value entry of the address. This is a two digit hex field. It is followed by either a carriage return, comma, or a circumflex (^).

Typical Lookup Table Addressing
(for up to 8 VID-4 cards)



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Each VID-004 card in the system contains a 256-position lookup table, stored in Page One memory as shown above. The Load Color Table instruction references these tables using relative addressing. For a system with only one VID card, load Table #0 from address 00_H to $1FE_H$. Tables 1,2, and 3 are also loaded from relative address 000_H to $1FE_H$.

LOAD INDEX

When this function is keyed, the present cursor coordinates are entered in the Index register. The Index is used for drawing vectors and circles.

The index location is used as the center of the circle, and the X coordinate of the index helps define the radius of the circle.

The index location defines the starting point of a vector.

See CIRCLE, VECTOR.

LOAD KEYBOARD BUFFER - LKB

This function is used to load the Keyboard Buffer. Two fields follow this function.

The first field is the starting address of the Keyboard Buffer given as a five-digit hex number. The address field is ended with a carriage return.

The second field contains the Keyboard Buffer data. Any keystroke typed will be entered into memory at the address specified in field one and the address pointer incremented. The last entry in the Keyboard Buffer should be a Terminate Keyboard Buffer (TKB) function key. This writes a Terminate code in the Keyboard Buffer and also terminates operation of the Load Keyboard Buffer function.

The acceptable address range for loading the Keyboard Buffer depends on the particular hardware configuration. If the system has Expansion RAM, any address in Expansion RAM is allowed; if there is no Expansion RAM, any address between $72CC_H$ and $7FFF_H$ can be used.

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LUT #1

This key loads the video lookup table of the VID-004 card with a "half identity table." That is, the first 100 hex addresses are loaded with half the value of the address. For example, the value contained in the zeroth entry equals zero, the value contained in address 02_H equals 01, etc.

The addresses are given as nine-bit values on word boundaries (low bit always equals zero). The color values are eight-bit values: three red, three green, and two blue.

The second 100 hex addresses are loaded with half intensity white.

Since the high address bit is AND'ed with a blink oscillator, this gives the effect of blinking between a half intensity white and the color specified in the low eight bits of the nine-bit address.

Only the zeroth VID-004 card is loaded by this function. To load individual addresses of the lookup table, see the LOAD COLOR TABLE description.

LUT #2

LUT #2 loads a set of default values into the VID-101 lookup table such that memory inputs 0 to 3 drive the blue color gun, memory inputs 4 to 7 drive the green gun, and memory inputs 13 to 15 plus cursor #2 drive the red gun. This has the effect of making the lookup table in an appropriately configured system "transparent," i.e., it appears as if the memories are connected directly to the DACs.

MEMORY

This function provides a means of storing data in memory. There are three fields of input expected when the Memory function is keyed.

The first field is one digit, either zero or non-zero. This is a switch which specifies the data input format. If a zero is entered in the first field, data is entered in words (four-digit hex) in the third field. If non-zero is entered in the first field, the data in the third field is entered as bytes (two-digit hex).

The first field is ended by a carriage return.

The second field is the address where the data is to be stored. This is a five-digit hex address, but it is unnecessary to type all five digits each time an address is

entered. The input is right-justified in a five position field. The most significant digit is the Device Select digit. The highest hex digit is 0 for every device except the VID card (for which the highest digit is set to 1 hex), and the Expansion RAMS (for which the highest digit is set according to the system configuration).

The second field is ended by a carriage return.

The third field is the data field. It contains either two or four digits, depending on what input format was selected in the first field. If a zero was entered in the first field, the data in the third field is entered in words (four-digits hex). If the first field is non-zero, the data in the third field is entered in bytes (two digits hex).

The third field is ended by either a carriage return, a comma, or a circumflex (^).

If the third field is ended by a carriage return, the data is entered into the specified address and the address pointer is incremented. The Memory function is reset to the same state it was in after the address field was terminated by a carriage return. When the data is entered in bytes, the address is incremented by one; when the data is entered in words, the address is incremented by two.

When the third field is ended with a circumflex, the data is entered and the address is decremented (by one for byte mode, by two for Word mode). New data may then be entered in the field.

See figure C-1 for the 5216 System Memory Map. (Appendix)

MODE - ADD/REPL

This function key chooses either Add or Replace mode for data entry. These modes correspond to the Memory Input Mode in the instruction set (Mode Control Word bits 5 to 7).

The three Memory Input Modes available are Add, Erase, and Replace. Selecting any one of these three modes will automatically deselect the other two.

In addition, when Replace mode is selected, either Replace Normal or Replace Reverse may be selected using the Background (BKGD) key.

See ADD, REPLACE, ERASE.

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MOVE GRAPHIC - MOVE G

This function places the system in Graphic Display mode (same as MCW bit 0 = 1), but does not cause a dot to be drawn at the present cursor location.

If Write Graphic is in effect when this function is called, the dot writing will be disabled.

This function must be selected when loading the pixel registers from the Pallet.

(Refer also to footnote under WRITE GRAPHIC - WRIT G.)

NON-DESTRUCTIVE - N-DEST

This function selects a Non-destructive mode for scroll and roll. Data moved off the screen in scroll and roll will be saved by a wrap around.

PALLET

This function displays a pallet of colors on the screen in the range between the pixel value stored in the FPR and the value in the BPR.

The colors displayed by the pallet are the colors currently loaded in the color lookup table. When the pallet is used to enter values in the pixel registers, the number entered will be the pixel value which corresponds to an address in the color table. The actual color value displayed by this pixel value will change if that address in the color table is reloaded.

The display is done in solid 7 x 9 blocks, starting in the bottom right of the rectangular window.

The pallet may be used to load values into the pixel registers (see Foreground and Background Pixel).

PIXEL

This function places operation of the display system into Pixel mode (see MCW bit 1). In this mode, data is addressed one pixel at a time. The alternative to Pixel mode is Word mode, which addresses 16 pixels on word boundaries.

When Pixel mode is selected, the pixel values stored in the Foreground and Background Pixel Registers are used as data

input values. See Replace, Add, and Erase modes for further details.

Pixel mode is deselected by selecting Word mode. In Word mode, the values in the pixel registers are not utilized.

PROGRAMMABLE FONT - PROG

Pressing this key selects the Programmable Character Font, and has the same effect as selecting the Programmable Character Font in the Mode Control Word (MCW) of the instruction set.

When this mode is selected, the normal alphanumeric keys will cause the display of programmed characters.

Programmed characters must be loaded from the host computer using the Load Programmable Font (LPF) instruction. The ASCII code of the alphanumeric key selects the matching character code of the programmed character.

REPLACE - REPL

In Replace mode, input data is written into picture elements without any retention of existing data.

In Replace Normal mode (see BKGD key), input data for vectors, circles, and write graphics is written to display memory using the pixel value in the Foreground Pixel Register (FPR). Characters in Replace Normal mode are generated using the value in the FPR to draw the character, and the value in the BPR to draw the background block.

When Replace Reverse is selected (see BKGD key), the vector, circle, and write graphic data is input in exactly the same manner as in Replace Normal.

For character generation, input data is reversed in Reverse Replace so that the character is written from the BPR, and the background block is written from the FPR.

The above rules are true if either the Pixel or Word mode is selected. However, in Word mode, the FPR is effectively all 1's and the BPR is effectively all 0's.

See MODE.

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RIGHT BOTTOM CONIC - RBC

This key is used to fix the current position of the cursor as the right bottom of the conic limit rectangle.

RIGHT BOTTOM RECTANGLE - RBR

The cursor is moved to the desired position and this function is keyed to fix the right bottom of the rectangular window in which drawing is permitted.

The rectangular limits may be set at any time anywhere on the screen without affecting data already displayed.

Data may be added or deleted only within the specified rectangular limits. For example, the Clear function key will clear only those pixels located within the rectangular limits. To enter data outside the rectangular limits, Clear Rectangular Limits (CRL) must be keyed.

ROLL - LEFT and RIGHT

This function rolls data within the rectangular window to the right or left, depending if it is keyed without or with a shift, respectively. Data is moved one pixel each time the function is keyed.

If Destructive mode is selected, data rolled outside the window will be lost; if Non-Destructive mode is selected, data rolled outside the window will wrap around to the other side of the window.

The Roll function will repeat if held down simultaneously with the Fast Repeat key.

SCREEN - XMIT

In Graphic mode (see Keyboard (KBYD) key), this key transmits an ASCII code ($9C_H$) to the host computer.

The keytop engraving (SCREEN - XMIT) refers to transmitting data from the Alphanumeric Channel Set (ANCS). This is only used when the ANCS is being programmed directly, i.e., KYBD key set to Alpha mode. (See ANCS user's documentation.)

See XMIT.

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SCROLL - UP/DOWN

This function scrolls data up and down within the rectangular window. Data is scrolled one pixel each time this function is keyed.

When Destructive mode has been selected, data scrolled outside the window will be lost; when Non-Destructive mode is in effect, data scrolled outside the window will wrap.around.

The Scroll function will repeat if held down simultaneously with the Fast Repeat key.

SELECT CHANNELS - SEL CH

Major and minor channels are selected by this function.

To select major channels, this function is typed with no shift, followed by a four-digit hex word which specifies the major channels* selected. The entry is followed by a carriage return. A 1 bit in the low order position of the 16-bit word selects the low order memory planes. Bits are ignored if their position in the selection word is higher than any corresponding memory plane in the hardware configuration.

To select minor channels, type the Select Channel function with a shift, followed by a one-digit hex field in which each of the four bits corresponds to a minor channel. The parameter field is ended by a carriage return. Not all hardware configurations permit selection of minor channels.

Data will be displayed from all channels, but only selected channels are accessible to incoming data. No changes, deletions, or additions may be made to unselected memory channels.

The Power Up value of memory select is all major and minor channels selected.

* Major channels correspond to RMM-001 Refresh Memory boards and minor channels correspond to banks on these boards.

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SPECIAL SYMBOLS

This function causes the special symbols which are printed at the upper right of the alphabetic keytops to be displayed

when the keys are typed with no shift. These special symbols include the Greek alphabet and other characters such as the summation sign and the divide sign.

When the keys are typed with a shift, the lower case alphabet and other special symbols printed at the top left of the keytops will be displayed.

These characters will all be displayed in a 7 x 9 font size.

TERMINATE KEYBOARD BUFFER - TKB

This function places a $9B_H$ in the Keyboard Buffer, and terminates operation of the Load Keyboard Buffer (LKB) function.

When the Keyboard Buffer is executed (XKB), the $9B_H$ is used to terminate the execution.

The second field of Load Keyboard Buffer must be open when TKB is used.

VECTOR

Keying the Execute Vector function results in a line drawn between the Index location (see LOAD INDEX entry) and the cursor location. The cursor position is not changed, and the index position is relocated to coincide with the cursor.

Vector writing utilizes Memory Input Mode. When Pixel mode is selected, vector data is input as follows:

In Replace Normal and Replace Reverse, pixel data is written to the display memory from the Foreground Pixel Register (FPR). In Add mode, vectors are written from the FPR and OR'ed with the data already written in display memory.

In Erase mode, vectors are input as if Replace Normal had been selected, except that input data is given by the value stored in the Background Pixel Register (BPR).

If Word mode is selected, the above Memory Input Modes will use all 1's as the FPR value, and all 0's as the BPR value.

Notice that Execute Vector from the host moves the cursor to the index coordinates after the line has been drawn.

VERTICAL REPEAT - VERT RPT

If the Vertical Repeat key is held down simultaneously with any character (with or without a shift), a "back-space- linefeed" will be performed repetitively so that the appearance of the screen display will be vertically repeating.

WORD

In Word mode, the FPR is effectively set to all 1's, and the BPR is effectively set to all 0's.

The values in the pixel registers are not lost by selecting Word mode and will be restored when Pixel mode is selected.

In Word mode, a function is set in the 5216 which writes a word (16 pixels) at a time. This is time efficient for character display since it is faster to generate characters by masking a sequence of 16-bit words than to generate each pixel individually.

Word mode may be deselected by selecting Pixel mode. This will restore the values most recently stored in the pixel registers.

In Word mode, display colors may be changed by selecting memory channels.

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WRITE GRAPHIC - WRIT G

This function causes dots to be drawn at every dot on which the cursor is positioned. Such dots will be drawn regardless of what is causing the cursor to move (i.e., cursor keys, trackball, or joystick).

If the system is in Alphanumeric display mode* when this function is called, it will be changed to Graphic display mode.

In order to turn off the dot drawing function while maintaining the system in Graphic mode, MOVE GRAPHIC (MOVE G) may be selected. Also, the Write Graphic function will be deselected by keying any of the Font Select functions.

Input data is taken from the FPR when in Replace Normal, Replace Reverse, and Add. Input data is taken from the BPR when Erase mode is selected.

When Word mode is selected, the FPR is effectively all 1's, and the BPR is effectively all 0's.

* The display mode refers to the 0 bit of the Mode Control

Word in the instruction set. This is not the same as the Graphic/Alphanumeric key. The alphanumeric key selects the A/N channel set (ANCS), which has its own processor and which requires its own instruction set. The graphic function key selects the processor and instruction set of the 5216 Standard Firmware.

XMIT

The two red keys marked XMIT cause keystroke data to be stored in the 5216 output buffer.

When the host is ready to receive keystroke data, a seven-word message will be sent to the host in accordance with the Keyboard Transmit Status (KTS) transmit format.

If the keyboard is in Graphic mode, the XMIT keys will have no direct effect on the 5216 Display Computer, and no display command is issued to the 5216.

If the keyboard is in Alphanumeric mode, the XMIT keys will issue display commands to the ANCS in addition to causing a keyboard transmit interrupt to be sent to the host computer.

The XMIT keys will cause output data to be stored in the output buffer regardless of the state of the KTS instruction. They may not be locked out.

See BUFFER, CURSOR, LINE, and SCREEN.

ZOOM

This function performs a 2 to 1 magnification of data within the rectangular window. Starting from the center of the window, all distances from pixel to center are doubled. Any data pushed outside the window by this function will be lost.

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KEYBOARD OPERATION

Initial Startup

To commence operations proceed as follows:

a. Press the INIT button (small button on the processor card of the 5216).

b. Check that the keyboard is connected directly to the 5216 processor board by keying KYBD-GRAPHIC, no shift.

c. Then, operate the following keys:

Key	Comments
LUT#1, shift	Load identity lookup table
CLEAR, no shift	Clear screen

Escape

To escape any key, press the ESC key. If the system appears to hang up, press the ESC key to abort any key which may be waiting for data.

Shift/No Shift

Except for three keys (CLEAR, LOAD INDEX, and LOAD COLOR TABLE), each function key performs two functions. One function operates when the key is pressed while SHIFT is held down, and the other function operates when the key alone is pressed. The function described at the top of the key is called when the key is pressed along with SHIFT, and the function scribed on the bottom of the key is called when the key is pressed with no SHIFT.

For CLEAR, LOAD INDEX and LOAD COLOR TABLE, no SHIFT is required.

Repeat

All character keys and the cursor control keys will repeat at the rate of 10 times a second after they are held down for more than 1/2 second.

Limits

To set window limits, use the Left Top Rectangle (LTR) and Right Bottom Rectangle (RBR) function keys. The system uses two rectangular limit windows, one for all data input and one for conics (vectors and circles). The conic limit rectangle is set by using the Left Top Conic (LTC) and Right Bottom Conic (RBC) function keys. The Power Up limits are set to the full screen.

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Conic limits are used to clip circles so that only a desired arc of the circle will be displayed. Since the cursor cannot escape the rectangular limits, conic limits which exceed the rectangular boundaries should be set first, and then the rectangular limits may be selected.

Cursor Movement

The cursor is moved by four arrow keys, the HOME key, and the CENTER function key; it can also be moved by an optional joystick or trackball.

In addition, when a character font is selected, the cursor automatically advances by the font width in the +X direction after each character entry and by the font height in the +Y direction when the right side of the drawing limit is exceeded. The X coordinate of the cursor is restored to the left side of the limit rectangle after the line advance.

The cursor arrows will move the cursor one pixel at a time when WRIT G or MOVE G is selected. When one of the character fonts is selected, the cursor arrows will advance the cursor in increments equal to the dimensions of the font.

Diagonal movement of the cursor is provided by keying any two adjacent arrow keys.

The cursor keys will automatically repeat at the rate of 10 times per second after being held down for more than 1/2 second.

The cursor cannot be moved beyond the rectangular limits. If it is necessary to move the cursor beyond these limits, the Clear Rectangular Limits (CRL) key must be used.

Graphic Possibilities

Using the keyboard function keys, the operator may draw lines (VECTOR and WRIT G), circles, and arcs. Arcs are drawn by using the Circle function and limiting the drawing to the appropriate arc by specifying conic limits.

Alphanumeric character capabilities include specification of five different character fonts including 5 X 7, 7 X 9, 10 X 14, special characters (size 7 X 9), and a programmable font which must be loaded from the host computer.

Characters are written in two colors - foreground for the character and background for the font block.

Also, enclosed areas of the screen may be filled, the screen can be zoomed (doubled), and sections of the screen display can be copied and displayed in other sections. The Copy function will test pixel values and then copy only those values or value ranges specified by the operator.

Color Control

Color may be selected in three different ways, using Foreground and Background Pixel Registers, Load Color Table and Selected Memory channels:

a. With all Memory channels selected (FFFF) and the Color Table loaded to the identify table (by keying the LUT#1 function), colors may be selected by loading the desired color values into the Foreground and Background Pixel Registers. When Pixel mode is selected, these values are then used for data entry. (Refer to ADD, REPLACE and ERASE mode for a detailed explanation of data entry).

b. Any element of the video lookup table may be individually loaded by using the LOAD COLOR TABLE function key. Any address may be loaded with any color value so that the actual color displayed for a given pixel value will be the value loaded in the Color Table at the address referenced by the pixel value.

For example, if address 000E of the Color Table is loaded with the color value 00C0, a picture element having the value 0007 will reference address 000E of the Color Table, and value 00C0 will be the color value actually displayed.

c. The third means of color selection is by memory channel selection. Word mode should be selected so that 1's will be entered for all selected memory channels.

If the identity lookup table is loaded, for example, and if memory channels 0007 hex are selected, then a Clear to 1's will load 1's into the low order three memory channels, and the screen will be solid red (except where data exists in other planes by previous input).

Another use for channel selection is to load the lookup table such that different color sets are available to the low three and the high five memory channels and then make use of the overlay priority of the VID-004 card.

Other Functions

Two programmable functions are available in the function key set:

a. The Keyboard Buffer function is used to store keystrokes, including function keys and cursor moves and to play back and execute the keyed commands upon issue of an Execute Keyboard Buffer (XKB) command.

b. There is also a function which executes a Cache Buffer. The cache comprises a list of 5216 Standard Firmware instructions which must be loaded from the host computer. The Cache Buffer can also be loaded with 8086 machine code instructions which may then be executed by keying the Execute Cache Buffer (XCB) function.

Examples

The following are examples which will aid in understanding the various functions described in this section:

a. To draw a vector:

Key	Comments
MODE-REPL, no shift	Selects Replace mode.
PIXEL, no shift	Selects Pixel mode.
F/PIXL, no shift	Loads Foreground Pixel Register (FPR).
FFFF	Any four-digit hex value - exact results depends on hardware configuration.
CR	Closes F/PIXL data field.
Move cursor using arrows, HOME or CENTER	Moves cursor.
LOAD INDEX, no shift	Locates start point of first vector.
Cursor arrows	Locates end point of first line.
EXECUTE VECTOR, no shift	Connects beginning and end points.

Optional: Load another color in F/PIXL

Cursor arrows	Draws more vectors connected end-to end.
EXECUTE VECTOR	

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b. To fill an enclosed area:

Key	Comments
Move cursor to interior of area	Must be within lines already drawn on screen.

F/PIXL	Sets color.
XXXX	Any four-digit hex color value.
7 CR	Closes data field.
FILL	Fills enclosed area with value in the FPR.

c. To load Pixel Registers from pallet:

Key	Comments
F/PIXL (no shift)	Loads FPR.
FFFF	All 1's.
CR	Ends data field.
B/PIXL (no shift)	Loads BPR.
0000	All 0's
CR	Ends data field.
PALLET (shift)	Calls pallet display.
MOVE G	Places system into Graphic mode.
Cursor arrows	Locates cursor over desired color value.
F/PIXL	Loads FPR.
^	Enters pallet value into register.
Cursor arrows	Locates cursor over desired color value.
B/PIXL	Loads BPR.
^	Enters pallet value into register.

d. To write characters:

Key	Comments
10 X 14 (no shift)	Selects font.
Cursor (arrows)	Locates start of first character.
Character	Types character.

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e. To load keyboard buffer:

Key	Comments
LKB shift	Loads Keyboard Buffer.
04000	Start address of buffer memory.
CR any combination of characters, cursor moves, vectors, etc.	
TKB shift	Terminates Keyboard Buffer.
. . .	Any sequence of function and alphanumeric keys.
XKB shift	Executes Keyboard Buffer.
04000	Start address of buffer memory.
CR	Ends data field, starts execute.

Serial Input Output Module (Optional)

With the optional Serial I/O module, the 5216 can support up to 10 keyboards. Each SIO card can interface with four keyboards and the 5216 can contain up to two SIO cards. There are also two connectors on the processor card.

At Power Up, each keyboard is associated with a parameter set. These keyboard-parameter set associations may be changed by loading the desired ordering of so-called "context switches" into 5216 memory using the Load Cache Buffer (LCB) instruction.

The list of keyboards, the parameter set with which each keyboard is associated at Power Up, and the context switch associated with each parameter set is given below.

Connection Card	Connector	Keyboard No.	Parameter Set (decimal)	Context Switch (Hex)
Processor	J4	1	1	2
Processor	J5	2	2	4
S101	J1	3	3	6
	J2	4	4	8
	J3	5	5	A
	J4	6	6	C
S102	J1	7	7	E
	J2	8	8	10
	J3	9	9	12
	J4	10	10	14
			11	16
			12	18
			13	1A
			14	1C

At Power-Up, the host is associated with parameter set 0. The desired order of parameter sets can be selected by loading the 10-word list of corresponding context switches (see table above) into 5216 memory starting from address E08B0. Use the LCB instruction to place data in 5216 memory.

For example, loading the following list of context switches into 5216 memory starting at address E08B0 will result in a new list of associations between keyboards and parameter set as noted.

Example:

Memory Address (Hex)	Context Switch (Hex)	Keyboard Number (Decimal)	Parameter Set (Decimal)
E08B0	12	1	9
E09B2	6	2	3
E08B4	4	3	2
E08B6	A	4	5
E08B8	C	5	6
E08BA	E	6	7
E08BC	E	7	7
E08BE	12	8	9
E08C0	14	9	10
E08C2	8	10	4

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SECTION 18

INSTRUCTION SET PROGRAMMING

Parameter Sets

A current set of parameters may be selected by calling the Start of Message (SOM) instruction. While this particular set of values is current, any change made to any parameter included in the list will be retained as the current value for that parameter in the selected parameter set.

For example, if an SOM instruction with operand 01 is issued, then the rectangular limits subsequently selected will be retained in parameter set 1. Then if SOM 2 is selected and another rectangular window is chosen, the retained value in parameter set 1 will not be changed. When SOM 1 is issued again, the rectangular window which was selected while in SOM 1 will become effective. This is true for all of the parameters contained in the parameter set.

Each parameter set has its own retained list of the following:

Parameters

- MAJOR Channel Selects
- MINOR Channel Select
- MAJOR Channel Mask
- Minor Channel Mask
- Mode Control Word
- X - cursor position
- Y - cursor position
- X - index
- Y - index
- Foreground pixel value
- Background pixel value
- Rectangular limits
- Conic limits
- ACA values
- KTS word

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This feature is especially important in interactive applications since each keyboard has access to only one parameter set.

Parameter sets may also be used to establish a rectangular window for alphanumeric data at the bottom of the display and graphic data on the remaining portion of the screen. Then, instead of redefining the Mode Control Word (MCW) and rectangular limits every time the display type is changed, the programmer can go back and forth between parameter sets.

Since the changes made in one parameter set will not be seen in any other parameter set, the programmer must issue desired parameter values such as rectangular limits, channel selection and MCW whenever a parameter set is selected for the first time.

Generalized Program Structure

Typical instruction sequences are indicated in Figure 18-1. Initializations which must be performed are the loading of the programmable

font and lookup table. The mode selection determines whether alpha-numeric or graphic data is to be subsequently entered, and determines also the Memory Input Mode (OR 1's, Replace, Erase 1's). If Pixel mode is selected, the Foreground and Background Pixel Registers should be loaded. Once the channels are selected and the limits specified, scrolling or clearing can be performed. The remaining sequences show the parameters which must be specified before vectors/conics and characters or graphics may be written.

Loading Characters

Characters may be loaded into the refresh memories either of two ways. Single characters may be written using the (Load Alphanumeric Characters) LAC instruction. In this mode, characters may be placed at random into the refresh memories. Large blocks of characters can be written using the BXM or XBXM instruction followed by the desired data words. In either case, the MCW must be set to Alphanumeric mode (bit 0=0), with the desired font, input mode, and cursor advance (ACA or normal) specified. Note that when ACA is not specified (MCW bit 8=0) the cursor advance will default to the predefined advance for the selected font.

In Word mode, when a character is written within 16 dots of the right limit, all or part of the character may be sliced off the right side of the character to preserve the limit specification. Similarly, any character written within one Y-cursor advance of the bottom limit will not be written into memory. In Pixel mode, characters will be clipped at the rectangular boundaries.

Example:

CODE (numbers are in hexadecimal)	DESCRIPTION
MCW, 90	Alphanumeric Mode, 10 x 14 Font, Replace, No ACA, Word Mode
SMC, 7	Select desired channels
EDT, 02	Clear Screen (Home Cursor)
BXM, 5	Block Transfer Mode - five words
	Note that by specifying five words, we will transfer ten characters (two per word)
0813 2005 1511 0309	Alphanumeric data. Note that the letter specified by 13 hex ("T") will appear first. Bit 2 in MCW can be set to reverse this order. Message = "THE QUICK"

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Loading Graphic Data

Graphic data can be written into the refresh memories in contiguous groups of up to eight bits, using (Load Graphic Elements) LGE; or in 16-bit words, using BXM (graphic Block Mode Transfer). When using LGE or BXM, the Mode Control Word must be set for graphic data, and an input mode must be specified. Adjustable Cursor Advance (ACA) is always used for LGE. Cursor advance for BXM is always 16 in the X direction and 1 in the Y direction. Automatic incrementing of Cursor-Y and resetting of Cursor-X is done when Cursor-X exceeds the right limit. In Pixel mode, BXM is performed pixel by pixel in the direction determined from the ACA. (See BXM Pixel mode.)

For LGE and BXM Word mode, graphic data must be specified such that the Least Significant Bit (LSB) of the input data will appear at the left side of the displayed data. In BXM Pixel mode, the LSB corresponds to the low order memory plane.

BXM can be used to send up to 2^{24} - 1 words of data.

Loading Conics

Vectors (straight lines) and circles are generated by the 5216 Standard Firmware when an Execute Conic (EXC) command is issued. Proper conic limits must be specified. No vector or circle data will be entered outside the currently specified conic limits.

Writing Indexed

If bit 9 (I) of the LGE or LAC instruction is set, the data will be written at the location found by adding the index registers to the cursor registers. The index registers can be loaded by the LIX and LIY instructions (Load Index Registers X, Y, respectively).

Limit checking for indexed instructions is done before the index is added to the cursor. As a result, data can be written outside the specified rectangular limits.

Programmable Font

The following example will illustrate the programming of a particular character into the programmable font memory:

CODE	DESCRIPTION
LPF, 01 214F	Load programmable Font character 01 X_{adv}=16, Y_{pitch}=10, X_{pitch}=16 (15+1)

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Example:

CODE	DESCRIPTION
0000	
0000	
0420	
0850	Character Data
1088	
3F04	Note that the least significant
1088	bits will appear to the left
0850	on the display
0420	
0000	
0000	
0000	
0000	Fill words necessary to produce
0000	16 words after LPF instructions
0000	

The example above will produce the character () as illustrated in figure 6-1. The character will be written into refresh memory (with the MCW set for Programmable Font) upon execution of the LAC, 01 instruction.

Color Selection

Displayed color for a particular picture element is determined by the color value stored in the lookup table at the relative address referenced by the refresh memory data value for that particular picture element.

The pixel value stored in refresh memory is determined by the channels enabled at the time data was entered to that pixel and also, in Pixel mode, the pixel value of the entry data and the Memory Input Mode selected at the time of data entry.

The color values in the lookup table are user programmable. The VID-004 card may conveniently be loaded in a basic identity configuration from the keyboard function keys LUT #1 or LUT #2. (This may also be accomplished from the host by loading and executing a Keyboard Buffer for the LUT #1 or #2 function key.) For systems with other video cards, and for loading other configurations, the lookup table must be initialized each time the system is powered up by Load Lookup Table (LLU4), or Load Cache Buffer (LCB) instructions.

For Pixel mode, the Foreground and Background Pixel Registers should be loaded (LPXF, LPXB) for each parameter set used.

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Keyboard and Cache Buffer

Any allowed combination of instructions may be stored in 5216 memory and executed by command from the host or keyboard. Commands which require DMA, i.e., Block Transfer Mode, and commands which require

host transmits are not allowed.

Data Transmit Formats

The data transmitted to the computer from the Display Generator is normally formatted as an acceptable sequence of Display Generator instructions, so that such data may be retransmitted to the Display Generator. The TCO, XTCO, TSC, XTSC, TPX, RLU4, XRLU4, RCB and KTS instructions request data to be transmitted to the host computer. The keyboard transmit occurs only if the KTS instruction has enabled keyboard interrupt (except for the two red transmit keys which always send an interrupt). An error interrupt is transmitted when the 5216 Standard Firmware detects that the cursor has been positioned outside the limits, a masked channel has been selected, or a selected channel has been masked.

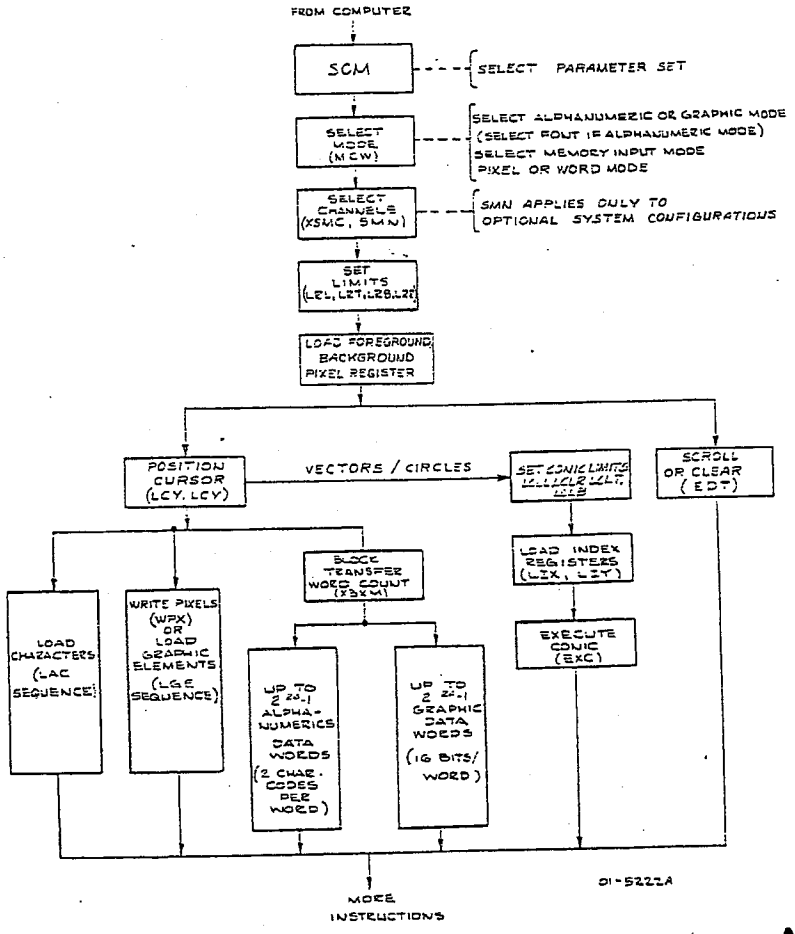

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Figure 18-1. Programming Structure